

Solubility with change in pH

1) a) Some sulfides have very low solubility products. When hydrogen sulfide gas is bubbled through solutions of these ions, these ions separate from a mixture of ions.

i) In a saturated solution of hydrogen sulfide $[\text{H}_3\text{O}^+]^2[\text{S}^{2-}] = 1.10 \times 10^{-23}$ Calculate the sulfide ion concentration when the pH of the solution is 4.20.

ii) Calculate the solubility of FeS in this solution, in mol L^{-1} . $K_s(\text{FeS}) = 4.90 \times 10^{-18}$

b) A solution contains a mixture of the two metal ions Cu^{2+} and Zn^{2+} , both of the same concentration. The solution is saturated with hydrogen sulfide and adding hydrochloric acid lowers the pH of the solution.

$$K_s(\text{CuS}) = 6.30 \times 10^{-36}$$

$$K_s(\text{ZnS}) = 1.6 \times 10^{-24}$$

Account for the fact that at a pH close to 7 all the metal sulfides will precipitate whereas only the most insoluble sulfides precipitate out at a lower pH.

In your answer, you should use equilibrium principles and both Cu^{2+} and Zn^{2+} as examples. (No calculations are required.)

2) Discuss the effect of decreasing the pH of the water on the solubility of $\text{Fe}(\text{OH})_3$.

3) A saturated solution of zinc hydroxide, $\text{Zn}(\text{OH})_2$ contains a small amount of solid $\text{Zn}(\text{OH})_2$ at the bottom of the container. The pH of the solution is increased. Discuss the effect of increasing the pH on the amount of solid present, and also on the nature and concentration of the species present in the solution. No calculations are necessary.

4) Discuss how the solubility of Ag_2CrO_4 will change if it is dissolved in $0.1 \text{ mol L}^{-1} \text{ NH}_3$ No calculations are necessary.

5) An aqueous ammonia solution has a pH of 10 and when phenolphthalein indicator is added it turns pink. Solid ammonium chloride is added to this solution and the solution turns colourless due to a decrease in pH. By considering the equilibrium systems, discuss why the pH of the solution decreased. Include a relevant equation in your answer.

6) a) Sea-water contains appreciable amounts of ions other than Na^+ and Cl^- . One substance that is less soluble than sodium chloride is calcium sulfate. This is precipitated in the first stage of the purification process used to produce table salt (sodium chloride). $K_s(\text{CaSO}_4) = 2.45 \times 10^{-5}$

Evaporating the sea-water to dryness would produce a mixture of salts including NaCl. However, precipitation of NaCl occurs if concentrated hydrochloric acid is added to a saturated NaCl solution. Explain why this precipitation occurs.

b) As part of the process for extracting table salt from sea-water, sodium hydroxide is added to the sea-water to precipitate the magnesium ions as magnesium hydroxide. The concentration of Mg^{2+} ions at this stage is 0.555 mol L^{-1} . Calculate the minimum hydroxide ion concentration and hence the pH of the solution needed for precipitation to occur.